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Final Technical Report for NASA Grant NAG 5-703

**The White Dwarfs and Inner Accretion Discs
of Three Unusual Dwarf Novae**

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This grant funded three IUE projects related to studies of cataclysmic variable stars and their accretion disks, under the IUE Guest Observer and Archival Research Programs. One study acquired and studied ultraviolet spectra of BV Cen, Z Cha, and OY Car, dwarf novae at the extreme ends of the orbital period distribution. The second study used archival spectra to study whether the ultraviolet energy distributions of novalike variables are adequately described by models of steady-state accretion disks that are based on either Kurucz stellar atmosphere fluxes or blackbody spectra. The third study acquired a spectrum of PG0027+260, an unusual eclipsing cataclysmic variable belonging to the SW Sex subclass. A small residual of grant funds remains unexpended. In 1990, the PI moved to the Pennsylvania State University; however, the grant has been continuously administered by the University of Arizona since its inception. Copies of all publications and presentations resulting from this grant have been provided previously to NASA/STIF, as enclosures with interim reports. A full bibliography is given below.

Well-exposed IUE spectra of the long-period dwarf nova, BV Cen, were obtained in 1995 August, supplementing weaker spectra obtained earlier by others. All of these were analyzed in Williger, *et al.* (1988), who studied the flux level and color of the ultraviolet spectrum, to establish upper limits to the temperature of the white dwarf and its contribution to the overall spectrum. The study concluded that the temperature of the white dwarf is likely to be low, that the disk likely contributes most of the UV flux at quiescence, and the disk in quiescence is more likely to be optically thick than optically thin.

Long exposures to obtain IUE spectra of the short-period dwarf novae Z Cha and OY Car were made in 1986 May. The LWR spectrum of OY Car was used in the study by Wood *et al.* (1989: ApJ, 341, 974) to help set an upper limit on the temperature of the white dwarf in that system. That study apparently did not take into account the photometric gain reduction that affects LWR spectra when the camera is operated at 4.5 keV instead of the nominal 5.0 keV ("ping avoidance"). The Z Cha and OY Car spectra, with correct photometric calibration, were both used (Wade, Cheng & Hubeny 1994) to study the absorbing effect of an "iron curtain" of cool material in the line of sight to the central white dwarfs in these systems. The OY Car iron curtain was very little different from the curtain present at the time of an HST/FOS observation reported by Horne *et al.* (1994: ApJ, 426, 294), in terms of gas kinetic temperature, gas density, or column density. The Z Cha spectrum showed an absorbing layer or curtain with similar temperature and density, but only a quarter of the column density of the OY Car layer. A by-product of the iron curtain analysis was preliminary estimates of the temperatures of the white dwarfs in these systems, to confirm the low temperatures found from optical studies. In a future work, this aspect of the study might be improved by requiring consistency of the solid angle for the white dwarfs, inferred by optical and ultraviolet means.

The second study, "Uniform Modelling of IUE Data for Cataclysmic Variables", resulted in a conference contribution and a paper (Wade 1987, 1988) that described the failure of simple accretion disk models to fit the UV spectra of novalike variables. This group of stars was appropriate for the study, because their disk sizes were known and their distances (as a group) could be established fairly well, so that both flux and relative energy distribution

could be used as constraints. It proved impossible to satisfy both constraints simultaneously, using disks whose fluxes were constructed from Kurucz stellar fluxes or blackbody spectra. This conclusion was shown to be statistically robust, and not limited to just steady-state disks, in the sense that no combination of fluxes satisfying an overall area constraint could satisfy both flux and color constraints. Left for further exploration was whether higher gravity or higher temperature models would help, or whether disk spectra are inherently unlike stellar spectra. This has been the subject of study under subsequent NASA grants.

Both the BV Cen study and the study of novalike variables made use of a preliminary study of archival data, given as a poster (abstract: Wade 1986), in which Kurucz's model fluxes were compared successfully with IUE spectra of *stars*.

The third study, "Characterization of Three Short-Period Binary Stars Using IUE", resulted in the awarding of time to observe the highest priority target. PG0027+260 was observed in 1990 July, and the UV spectrum was described and discussed in a major study of that star by Thorstensen *et al.* (1991). The UV spectrum is quite similar to that of other high-inclination disk systems, and supports the interpretation that the mass transfer rate through the disk is quite high.

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